

1 We claim:

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3 1) A diffractive structure which applies a specified complex-valued spectral filtering  
4 function to an input optical field and which emits a filtered version of the input field in an  
5 output direction, said diffractive structure comprising:

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7 a plurality of spatially distinct subgratings,

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9 each subgrating possessing a periodic array of diffraction elements.

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11 2) The structure recited in claim 1 wherein each of said subgratings has an amplitude,  
12 spatial phase shift, and spatial period ( $A_i$ ,  $x_i$ , and  $\Lambda_i$ ) and a transmissive optical phase  
13 shift ( $\phi_i$ ) introduced by a variation in substrate thickness or superimposed phase mask  
14 and wherein the amplitude and phase parameters of each of said subgratings is defined  
15 in terms of

$$a_i = \beta d \int_{m/(\beta\Lambda)-1/(2\beta d)}^{m/(\beta\Lambda)+1/(2\beta d)} \frac{T(v)}{F(v)} \exp(-j\pi(v\beta - m/\Lambda)(x_i^a + x_i^b)) dv$$

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18 in the sense that  $A_i$  is set by the amplitude of  $a_i$  and the phase of  $a_i$  sets a combination  
19 of  $x_i$  and  $\phi_i$ .

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21 3) An optical structure which applies a specified complex-valued spectral filtering  
22 function to the input optical field and which emits a filtered version of the input field in an

1 output direction said filtered output having a temporal structure essentially matching a  
2 reference optical waveform, said structure comprising,  
3  
4 a plurality of subgratings combining to form a segmented grating with a particular  
5 transfer function determined by said reference optical waveform.

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7 4) An optical structure which applies a specified complex-valued spectral filtering  
8 function to the input optical field and which emits a filtered version of the input field in an  
9 output direction said filtered output having a temporal structure essentially matching the  
10 cross correlation of the input field with a reference optical waveform, said structure  
11 comprising, a plurality of subgratings combining to form a segmented grating with a  
12 particular transfer function determined by said reference optical waveform.

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14  
15 5) An optical system for optical code division multiple access (OCDMA) for multiplexing  
16 and demultiplexing a plurality of optical signals in accordance with a set of reference  
17 optical waveforms, each reference optical waveform comprising a sequence of time  
18 slices, said system comprising grating devices each comprising  
19  
20 one or more segmented gratings,  
21  
22 each said segmented grating having a spectral transfer function determined by its  
23 constitutive subgrating parameters  $A_i$ ,  $\phi_i$ ,  $x_i$ , and  $\Lambda_i$  that matches a particular reference

1 optical waveform,  
2  
3 multiplexing multiple optical data streams by directing each onto to a specific segmented  
4 grating along its operative input direction thereby producing an output beam encoded  
5 according to the reference optical waveform encoded in said specific segmented  
6 grating,  
7  
8 demultiplexing a time-code multiplexed optical data stream from a OCDMA channel by  
9 directing said OCDMA channel along the operative input direction of a segmented  
10 grating encoded so as to direct said time-code multiplexed optical data stream in a time-  
11 code specific output direction.

12  
13 6) The structure recited in claim 1 wherein the spatial placement of the various  
14 subgratings is employed to control the spectral transfer function of the structure.

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16 7) The structure recited in claim 1 wherein the amplitude of the various subgratings  
17 control the spectral transfer function.

18  
19 8) The structure recited in claim 1 wherein the optical thickness of the various  
20 subgratings comprising the segmented grating is controlled by variation of substrate  
21 thickness, addition of segmented phase masks, or other means known in the art to  
22 control the spectral transfer function of the segmented grating.

23  
24 9) The structure recited in claim 1 wherein the addition of active devices as known in  
25 the art to dynamically change subgrating optical thickness, phase mask optical

1 thickness, optical transmission, or placement allow for the dynamical reprogramming of  
2 the subgrating parameters and thus the spectral transfer function of the segmented  
3 grating.

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5 10) The structure recited in claim 1 wherein the subgratings are transmissive gratings.

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7 11) The structure recited in claim 1 wherein the subgratings are reflective gratings.

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9 12) The structure recited in claim 1 wherein the subgratings comprise a planar surface.

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11 13) The structure recited in claim 1 wherein the subgratings comprise a non-planar  
12 surface shaped so as to map the input spatial wavefront onto a desired output spatial  
13 wavefront.

14

15 14) A method of applying a specified complex-valued spectral filtering function to light in  
16 an input optical field by passing said light through a structure which combines plurality of  
17 spatially distinct subgratings, each subgrating possessing a periodic array of diffractive  
18 elements, said subgratings combining to form a segmented grating with a particular  
19 spectral transfer function.

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21 15) A method of applying a specified temporal waveform onto an input optical field by  
22 passing said light through a structure which combines a plurality of spatially distinct  
23 subgratings, each subgrating possessing a periodic array of diffractive elements, said  
24 subgratings combining to form a segmented grating programmed to produce said  
25 specified temporal waveform.

2 16) A method of applying a specified complex-valued spectral filtering function to light in  
3 an input optical field by passing said light through a structure which combines a plurality  
4 of spatially distinct subgratings, each subgrating possessing a periodic array of  
5 diffractive elements, said subgratings combining to form a segmented grating with a  
6 particular transfer function that is given by the complex-conjugate of the Fourier  
7 spectrum of a reference optical waveform, whereby the light emitted by said structure  
8 in a particular direction has a temporal structure given by the cross-correlation of said  
9 reference optical waveform and the input optical field.